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AEROMEDICAL DATA ACQUISITION AND COMMUNICATION SYSTEM (AMDACS)

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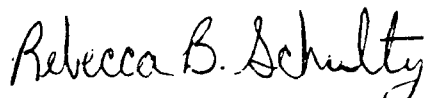
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19. ABSTRACT (Continued)

communication between echelons was developed. Problems associated with current data handling methodologies were identified and prioritized and potential solutions/enhancements recorded. A project roadmap was developed for a medical information and communication program to research information requirements and potential solutions which can be pursued as separate unique products.



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AEROMEDICAL DATA ACQUISITION AND COMMUNICATION SYSTEM (AMDACS)

1.0 INTRODUCTION

1.1 Background

The United States Air Force (USAF) Medical Service mission provides medical support necessary to maintain the highest degree of combat readiness and effectiveness of the Air Force. In 1979, a four echelon combat casualty care system was developed as the framework for the USAF Medical Service. Within this system, combat casualties receive medical care in a hierarchical system of discrete treatment episodes linked by the evacuation system to the next echelon of care. The level of sophistication of the diagnostic and therapeutic capabilities increases as the casualty moves from the lower echelons to the higher echelons. This system results in the generation of larger volumes of increasingly complex data to collect, record, and interpret as the casualty moves through the medical care system.

Considerable problems exist in providing current and relevant clinical information to permit timely action as the casualty moves rearward. At the lower echelons, problems encountered relate to an inability to adequately summarize findings or document actions taken during periods of peak activity or overload. The medical professional caring for these casualties work in relative isolation with little consultative support and austere resources. Critical sorting, return to duty, treatment, and evacuation decisions initiate a complex process which greatly impacts morbidity, mortality, and manpower conservation. Between the echelons, the responsibility for continuity of care resides in the aeromedical evacuation system which provides staging and nursing support. Current information is needed during the evacuation process to ensure continuity of medication and treatment regimes. At each receiving echelon, pertinent information is needed to facilitate efficient casualty reassessment and continuity of care. At any or all of these various treatment intervals, there is a great deal of data which is not summarized or presented in an orderly fashion. Written notes are not always clear and it is not easy to maintain a linkage between the casualty and the medical record.

In addition to the clinical data used by direct care providers, there are other USAF functions which need or could potentially use data abstracted from clinical records (e.g., personnel, patient administration, medical planners, epidemiologists, regulating offices). Opportunities exist to provide valuable data for use in trend analysis, intelligence gathering, or policy revision.

1.2 Project Objective

The overall goal of this project was to determine how to improve medical care through the collection, analysis, storage, presentation, and communication of clinical data within and between the echelons of care. In addition to providing needed clinical information to receiving echelons, an aeromedical data system should also provide support to movement priority and return to duty decisions and serve as a source of feedback information to forward echelons.

2.0 TECHNICAL APPROACH

The project was divided into three tasks. The first task produced a description of the USAF casualty care system and its information flow and identified areas of opportunity for enhancement and/or improvement. The second task was designed to identify the data and information needed to optimally care for casualties. Based on the results and recommendations from the first two tasks, the third task defined the actions necessary to plan and execute the next phases of development and acquisition process.

2.1 Task 1: Mission Analysis

The Preliminary Medical Mission Analysis and Preliminary Medical Information Analysis were primarily drawn from published concepts of the current combat casualty care system and work performed through previous related efforts. The Preliminary Medical Mission Analysis described the casualty care system, patient and information flow, major interfaces, medical decision support currently available, users of casualty data, and potential areas of significant improvement and/or enhancement. The Preliminary Medical Information Analysis was performed and "strawman" data flow diagrams were developed to depict the casualty care system and information flow. Resource constraints did not permit field studies or other active investigations of wartime medical operations. Both analyses provided provisional recommendations of areas for potential improvement and were designed to provide a point of departure for the Working Group. These analyses also served two other purposes for the Working Group: defining the USAF combat casualty care system (which differs somewhat from the capabilities of other Services at some echelons) and ensuring a commonality of terminology and concept definition.

The Preliminary Medical Mission Analysis and Preliminary Medical Information Analysis were later combined with the AMDACS Working Group findings to become the "Concept Development for an Aeromedical Data Acquisition and Communication System (AMDACS)" document.

2.2 Task 2: Concept Development

2.2.1 AMDACS Working Group Meeting

The AMDACS Working Group meeting was designed to analyze the technical and operational information needs relevant to patient care in the combat casualty care system. Various Department of Defense (DoD), government, and civilian activities were contacted to participate on the AMDACS Working Group based on their expertise and relevance to the effort. The Working Group consisted of experts in the areas of combat casualty care, trauma care, aeromedical evacuation, medical decision support systems, automated medical records systems, systems analysis, communications systems, biomedical engineering, and medical information systems. Working Group members were selected based on their knowledge of wartime/disaster casualty care, expertise in medical information and/or communications systems, or interest in developing an improved aeromedical data acquisition and communication methodology.

The AMDACS Working Group meeting was convened at Brooks AFB, TX, on 5-8 March 1990. During the meeting, the AMDACS Working Group reviewed a "strawman" casualty care data stream representation for relevance and priority of information requirements. A summary of information essential or critical for casualty care within each echelon and for communication between echelons was developed. Problems associated with current data handling methodologies were identified and prioritized and potential solutions/enhancements recorded. Qualitative measures of the costs associated with less than optimal processing of such information (e.g., care provider manhours required to reconstruct incomplete records for casualties evacuated to another echelon or medical treatment facility) were also evaluated. Finally, a representative project roadmap was proposed; plan, schedule, and milestone issues were discussed; and recommendations were recorded.

Active participation by the Working Group members began with the revision of the proposed data dictionary. Members were divided into three groups: first and second echelons, third through fifth echelons, and aeromedical evacuation. Each group formulated a list of data categories and data elements determined to be critical to group-specific concerns, reached consensus, and presented the results (the refined data dictionary of clinical information needs) to the entire assembly of participants for review and revision.

The Working Group again broke into three subgroups as before (although some migration of participants took place between the subgroups). This migration had two effects: communication between groups was facilitated and resources were applied where most needed. Each group examined all data categories and data

elements to define echelon-specific problems associated with the collection, recording, transmission, or use of the data. Group consensus was again reached and the results presented to the entire assembly. Results of these activities were compiled into a single document. Then, each Working Group member was given a copy of the consolidated problem list and was asked to individually rank each problem according to its criticality and to identify potential solutions where possible.

Several issues were identified from discussions held during the course of the meeting and from responses to questionnaires and critiques which warrant further review and consideration. A summary of these issues is as follows:

- Automation of data on the Field Medical Card.
- Automated interface with medical evacuation systems such as the Automated Patient Evacuation System (APES) and other medical information systems.
- Automatic generation of reports and other administrative requirements.
- Patient tracking and posttreatment assessment to provide system level feedback on four echelon capabilities.
- Automated collection, reduction, and trend analysis of clinical data for patient monitoring.
- Decision aids for health care providers at and between the echelons to support diagnosis, treatment, and disposition.
- Automation of patient history data storage and modification.
- Aeromedical evacuation specific data for air-to-ground transmission.
- Joint Service participation in the improvement of data collection, manipulation, storage, and transmission.

2.2.2 AMDACS Working Group Meeting Findings

The "Concept Development for an Aeromedical Data Acquisition and Communication System (AMDACS)" document published under separate cover provides an extensive discussion of the AMDACS Working Group findings.

2.3 Task 3: Project Roadmap

Over the course of the Working Group sessions, it became apparent that there was confusion relating to the purpose of the current effort and the use of the word "system" in the project title. This confusion created the impression that the project was aimed at designing, producing, and fielding a specific hardware/software product. While such a product (or a series of such products) could be conceived from this project, AMDACS was envisioned as a research effort designed to identify information requirements.

Therefore, a Project Roadmap was developed for a medical information and communication program. This program proposes to research information requirements and potential solutions which are then pursued as separate, unique products. These products could be studies and analyses which form the basis for policy/guidance/procedural changes, devices to assist providers in collecting casualty data, or hardware/software components to enhance existing medical automation systems. Developers for these user-defined products could be a lead agency (e.g., U.S. Army for chemical warfare defense), a specific Service (e.g., U.S. Air Force for aeromedical evacuation), or a Tri-Service organization (e.g., OASD(HA) for Joint requirements). The program was divided into 3 phases: (1) Requirements Definition/Analysis, (2) Development, and (3) Implementation.

2.3.1 Requirements Definition/Analysis Phase

Before a product can be developed or technologies evaluated, a clear, concise definition of the problem(s) must be developed. The AMDACS Working Group provided a broad overview of problems associated with collecting, recording, and communicating clinical data at and between each echelon. Candidate requirements for improving the flow of clinical data were extracted from the Working Group output and are summarized in Table 1. These candidate requirements need to be refined and validated with direct care providers while they are working in the setting being addressed. For example, a physician validating a data collection requirement at the second echelon (2E) could best perform that function during an exercise or demonstration. This task would be very difficult to accomplish with any validity while sitting at a desk in the office. In addition, specific requirements need to be validated by the appropriate functional expert(s) at each level of care being addressed (e.g., flight nurses/aeromedical technicians for AE requirements, emergency room physicians/nurses/technicians for 2E requirements). Some preliminary requirements validation could be accomplished using previous studies and analyses such as Medical Readiness Automated Data (MEDRAD) or Wartime Medical Work Center Description (WARMED-WCD). The final validation should, however, be accomplished in as realistic a setting as possible.

TABLE 1. SUMMARY OF USER REQUIREMENTS

CATEGORY	LEVEL	REQUIREMENT
Contamination	1-3	Personnel dosimeter that measures amount and type of exposure
	1-3	Field Medical Card (FMC) must endure decontamination solutions and procedures, yet require no special writing instruments
	1-3	Non-aqueous rapid casualty decontamination
	2-5	Methodology for inflight monitoring of casualties wearing nuclear, biological, and chemical (NBC) protective wraps
Administration	2-5	Nonmanual data capture that is compatible between echelons and Services; read and write capability; aeromedical evacuation (AE) inflight capability
	1-3	Modify the FMC to enable manual and nonmanual entries; compatible with capture as identified above
	1-5 AE	Improved mechanism to maintain the FMC with the casualty
	5	Automated system interface between DoD, Veteran's Administration (VA), and National Disaster Medical System (NDMS) hospitals
	2-5	Mechanism to scan or read FMCs and automatically generate mission paperwork
Disposition	2-5	Mechanism to track disposition data and automatically regulate casualties; provide movement coordination (i.e., equipment, medications, special care); interface with other available data systems
	2-5	Development of functional criteria (standards) for various Air Force Specialty Codes (AFSCs)/Military Occupational Specialty (MOSs) to aid return to duty (RTD) decisions

TABLE 1. SUMMARY OF USER REQUIREMENTS (CONTINUED)

CATEGORY	LEVEL	REQUIREMENT
Disposition	2-5	Development of RTD information packages/instructions for patients and commanders
Treatment	1-2	Automatically generated logs, trend analyses, RTD data, resource allocation, etc. for use by planners
	2-4	Improved decision support mechanisms to assist in treating uncommon conditions, injuries, and complications
	2-5	Improved clinical feedback mechanism; dissemination of information to providers
	AE	Onboard decision support systems to deal with inflight medical emergencies
	AE	Secure communication for transmitting data from aircraft to receiving MTF (i.e., encrypted digital burst)
Assessment	2-5	Improved mechanism to track assessment and diagnostic data, perform trend analyses, provide decision support
	4-5	Expert medical monitoring system with computer interface
Diagnostics/ Triage	2-3	Mechanism for performing triage while casualties and providers are in Mission Oriented Protective Posture (MOPP) gear
	2-4	Improved capability to obtain medically relevant historical information about the casualty
	2-5	Improved tools to assess effectiveness of triage process
	AE	Capability to assess large numbers of casualties for classifying and prioritizing movement

TABLE 1. SUMMARY OF USER REQUIREMENTS (CONTINUED)

CATEGORY	LEVEL	REQUIREMENT
Observations/ Therapy Response	3-5	Improved capability to handle multiple sources of data input/output, interdisciplinary crossfeed, and greater volumes of data
	AE	Improved communication of pertinent clinical information between originating medical treatment facility (MTF), AE personnel, and receiving MTF

After the requirements have been refined, a Statement of Need (SON) must be written. A SON signifies a user's desire to solve a problem and thus ensures programmatic commitment. A SON should be specific to a level of care and theater and should address specific scenarios (i.e., conventional, NBC, combined).

The SON provides the basis from which the Front End Analysis and Cost/Benefit Analysis are performed. The Front End Analysis is a conceptual study which investigates alternative solutions, methods, or technologies for satisfying the specified requirements. Important questions to ask are:

- Does the solution have functional utility? Does it really solve the problem?
- What are the operability issues? Can we really operate this way? What is the impact on present Concept of Operations?
- Is there any value in developing this solution? What is the collateral impact on medical care? Does it solve this problem only to create another one?

The Cost/Benefit Analysis addresses general support requirements and life-cycle costs associated with:

- Personnel
- Training
- Facilities
- Equipment/Supplies
- Reliability/Availability/Maintainability (RAM)

The end result of these analyses should be a prioritized list of products to be developed. Some of these candidate products will require quad-Service participation and coordination. In other

cases, North Atlantic Treaty Organization (NATO) coordination may be required on development efforts which impact the way the USAF Medical Service interfaces with its Allied medical services (e.g., DD Fm 1380 revisions).

2.3.2 Development Phase

Using the prioritized list of developmental products and the SONs, a Five Year Defense Plan (FYDP) for the Medical Information and Communication Program is developed (Fig. 1). The FYDP shows

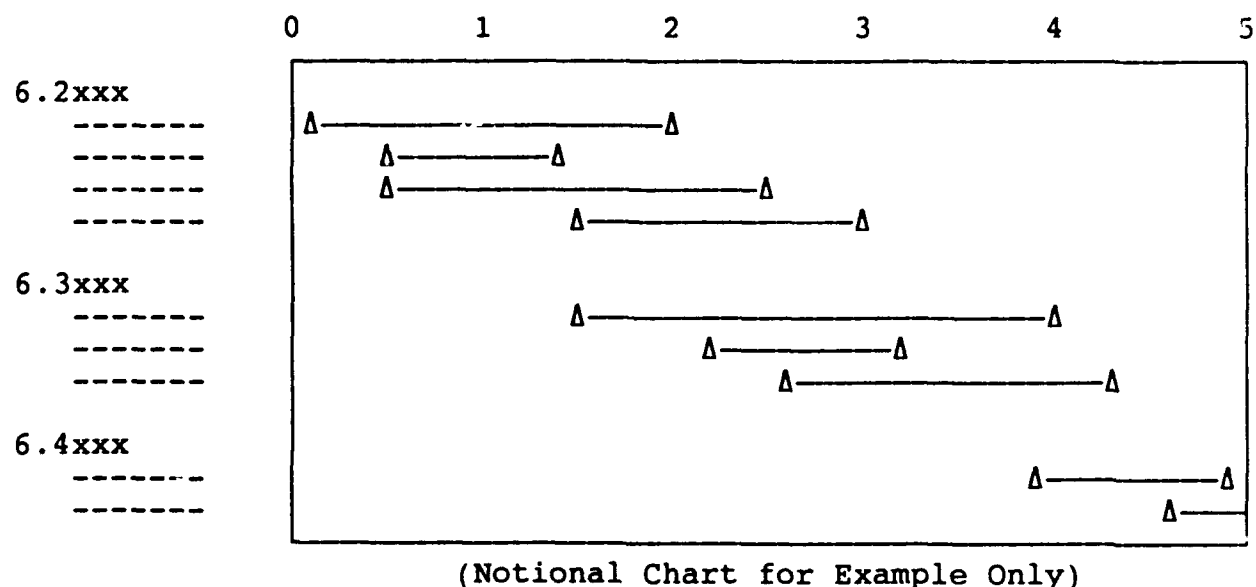


Figure 1. Representative Five Year Defense Plan.

the sequence by which 6.2 technical development products (e.g., voice activated recording) and most promising technologies (i.e., those applicable to specific products) are taken to the 6.3 prototype stage. Those 6.3 efforts that perform functionally as anticipated and are sound from the engineering perspective are taken to 6.4 full-scale engineering development and production. Early operational assessment needs to be conducted to ensure that the product(s) meet specified requirements and can be fielded in a cost-effective manner. User involvement throughout the process is mandatory (i.e., participation in development of the Test and Evaluation Master Plan (TEMP), observing and participating in developmental test and evaluation). Operational test and evaluation (OT&E) conclusively demonstrates operational effectiveness and operational suitability of the product(s) and provides a clear indicator of those products to be fielded.

2.3.3 Implementation Phase

An implementation plan and schedule for each product is developed which addresses the following:

- Identification of implementation sites.
- Training of site personnel in the use and maintenance of the product.
- Introduction of the product to the site.
- Observation and evaluation of operation.
- Development of user training (plans, materials, courses).
- Revision/development of policy/guidance.
- Development of maintenance procedures and depot criteria.
- Allocation of logistics support.
- Identification of Pre-Planned Product Improvements (P³I).

3.0 CONCLUSION

The function of research efforts such as AMDACS is the analysis of operations and procedures, the identification of problems and potential solutions, and the quantification of costs and benefits associated with such solutions. This kind of information is helpful, not only to the designers of new systems, but to those responsible for the maintenance and upgrade of current systems. In the case of AMDACS, the potentially greatest benefit is the capability to supply a unifying thread (based on the concept of clinical information requirements essential to achieve optimum treatment) to a number of different systems in the DoD medical community. Many of these systems, while not directly involved with casualty care (e.g., medical logistics, medical administration, regulating for aeromedical evacuation), need to share vital clinical information from care providers and may, in turn, provide data from their functional areas that directly impacts treatment and care. These and other issues that surfaced during this meeting warrant consideration not only in relation to the AMDACS effort but in relation to other systems and efforts as well.

Based on the results of this study, pursuit of the following efforts is recommended:

Aeromedical Evacuation Procedures in an NBC Environment.

Aeromedical evacuation (AE) in an NBC environment presents unique medical care problems which may require revised AE procedures or equipment. The purpose of this study is to investigate the impact on AE medical care procedures while operating in an NBC environment and to recommend enhancements, modifications, or development of new AE procedures and/or equipment.

Triage Effectiveness. Wartime triage of casualties requires the timely separation and treatment of minimally injured personnel to enhance return to duty. The sorting of casualties by severity of injury/illness is further complicated in an NBC environment. Training is required to achieve three objectives: (1) enhance the proficiency of medical personnel in performing wartime triage, (2) enhance the guidance/procedures for triaging mixed casualties (i.e., conventional, NBC, combined), and (3) develop procedures for triaging casualties while clothed in protective ensembles.

Enhanced Field Medical Data Entry. This initiative will apply existing data capture and data entry technology (e.g., bar codes and hand-held readers) to capture medical data in austere environments (i.e., 1E, 2E, MASF). This technology can be applied without altering the DD Fm 1380, U.S. Field Medical Card by applying bar code overlays and then using bar code readers. A similar procedure was used successfully to capture 1E and 2E data at the airbase survivability demonstration SALTY DEMO in 1985.

Medical Exercise Report Analysis. Medical exercises are held regularly worldwide and the results are recorded in after-action reports which are then forwarded to the respective major Commands. This effort will analyze recent medical exercise after-action reports to identify trends, lessons learned, problem areas, and "show stoppers." The results of this analysis can be applied to medical unit training programs to benefit from previous learning experiences and avoid known pitfalls.

Return to Duty Criteria. The Air Force Medical Service supplies the largest number of trained replacement personnel to fight the war by rapidly treating and returning to duty the minimally injured. However, established criteria are not available to guide providers, patients, and commanders on duty limitations and/or restrictions associated with specific injuries or illnesses. This project will identify specific criteria for personnel returning to duty and the level of activity appropriate for their injury/illness. These criteria will be identified for specific Air Force Specialty Codes (AFSCs)/Military Occupational Specialty (MOSs) by skill level.

Wartime Decision Support System. In wartime, surges occur which can present large numbers of casualties in a very short period of time. In these stressful situations, a medical decision support system can aid providers in identifying uncommon conditions, familiarizing them with seldom seen wartime injuries, and analyzing the potential for complications/harmful interactions. This effort will develop wartime decision support methodology for use in a field medical environment (i.e., 2E).

Clinical Information Feedback. Medical personnel at the lower echelons provide medical care as prescribed by the current

casualty care concept. Patients are then transported to higher echelons to receive further medical attention based on the medical condition and theater evacuation policy. Currently, no tried and proven mechanisms are available to provide the lower echelons with feedback regarding lessons learned, trends, quality of care, progress, and specific procedures that could be beneficial in dealing with wartime casualties in these austere environments. This effort will develop that feedback mechanism.

Aeromedical Evacuation Decision Support System. Due to the lack of physicians onboard AE aircraft and in Mobile Aeromedical Staging Facilities, AE crew members must rely on experience and training to deal with emergencies and degradation of condition in the AE environment. Theater and strategic AE of wartime casualties presents unique challenges. In the inflight environment, patients are exposed to known stresses of flight (i.e., noise, vibration, decreased partial pressure of oxygen, decreased humidity, temperature variations) which can adversely affect their condition and prognosis. This study will develop a decision support tool to provide AE crew members with indications of the threat associated with the inflight environment, anticipated complications, injury-specific restrictions, and recommended solutions for minimizing the stresses of flight.

Air-to-Ground Data Transmission. Aeromedical evacuation crews have a requirement to transmit patient and mission data to ground stations in preparation for arrival at the receiving medical facility. Due to the saturated command and control environment, this transmission of patient and mission data must be the minimum essential for effective patient movement and care. This project will identify the minimum essential data set that requires air-to-ground transmission, the time sensitivity of the data, transmission rates, and transmission priority.

Inflight/Mobile Aeromedical Staging Facility Medical Monitoring. Patient status and vital signs are key to patient movement decisions. Yet, the ratio of medical personnel to patient may not allow optimum observation, monitoring, and documentation of all patient care activities. This effort will identify the medical monitoring requirements associated with patient movement (MASF and AE); how these data are captured, processed, and recorded; and the medical data interoperability requirements necessary to allow networking of sensors and monitors.

Patient Medical History. Patient histories are important to effective health care delivery, but in wartime, the manual collection of patient history data is prohibitively labor intensive. This initiative will investigate technologies that can be applied to automatically record and transmit patient history. Current technology, such as passive data transceivers, can record a patient history (during peacetime) and burst the data during wartime. These devices have both read and write

capability, are no larger than a U.S. dime, can be attached to clothing or on a wrist band, and have very low EMI signatures.

Clinical Data Communication. The purpose of this effort will be to investigate the most effective way(s) of communicating clinical data between the lower echelons and AE components. The paper record can be supplemented with a variety of media such as magnetic disk, magnetic tape, voice communication, etc. Retention of clinical data will be enhanced with the investigation and resultant selection of supplementary media.

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